

FAME Orbit Transfer Plan

Jim Barnds

NRL

4/27/2001

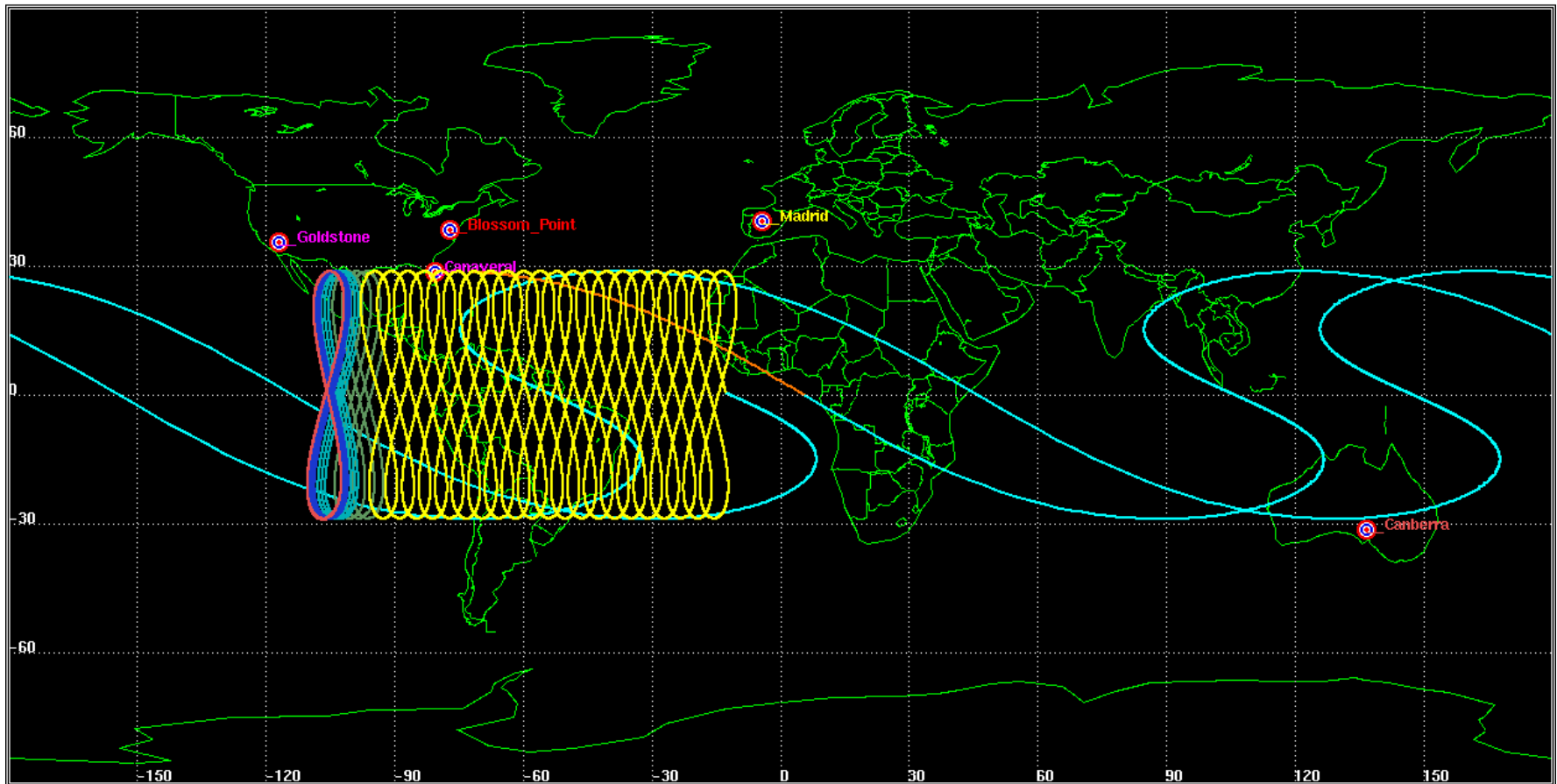
Orbit Transfer Plan

- Designed to deliver the FAME observatory to 105.5° West LAN in a stable orbit which minimizes ground track drift.
 - Fixes the mission orbit s.t. the minimum elevation over BP > 5°
 - Places constraint on ground track drift and orbit inclination.
 - Accomplished by timing of phasing maneuvers (including contingency planning) and accuracy of final orbit insertion.
- Changes from prior plan:
 - GTO ground track has shifted west (Boeing update for descending node maneuver into GTO).
 - Smaller inclination range expected from insertion errors.
 - AKM attitude within 2° of nominal
 - Maximum expected inclination of 30.8°
 - Allows LAN drift up to 110° West.
 - Allows less precise final maneuver

Overview

- Launch Date 10/30/2004 21:19:36 (All times are GMT.)
 - Injection via Delta-II 2925 into 185 x 36106 km GTO (1.5 days)
- Trim the GTO apogee after 2 revs during perigee swing-by.
- AKM firing to nominal +320 km Supersynchronous orbit (days)
- Trim the SuperGEO orbit and drop AKM.
 - May have to jettison immediately. Under analysis
- Drift on SuperGEO for 19.6 days
- Use 11 days on phasing orbits to get desired LAN and minimize LAN drift rate.
- Transfer observatory to GEO +335 km for disposal after 5 years

FAME Ground Track for Nominal Orbit Transfer Plan



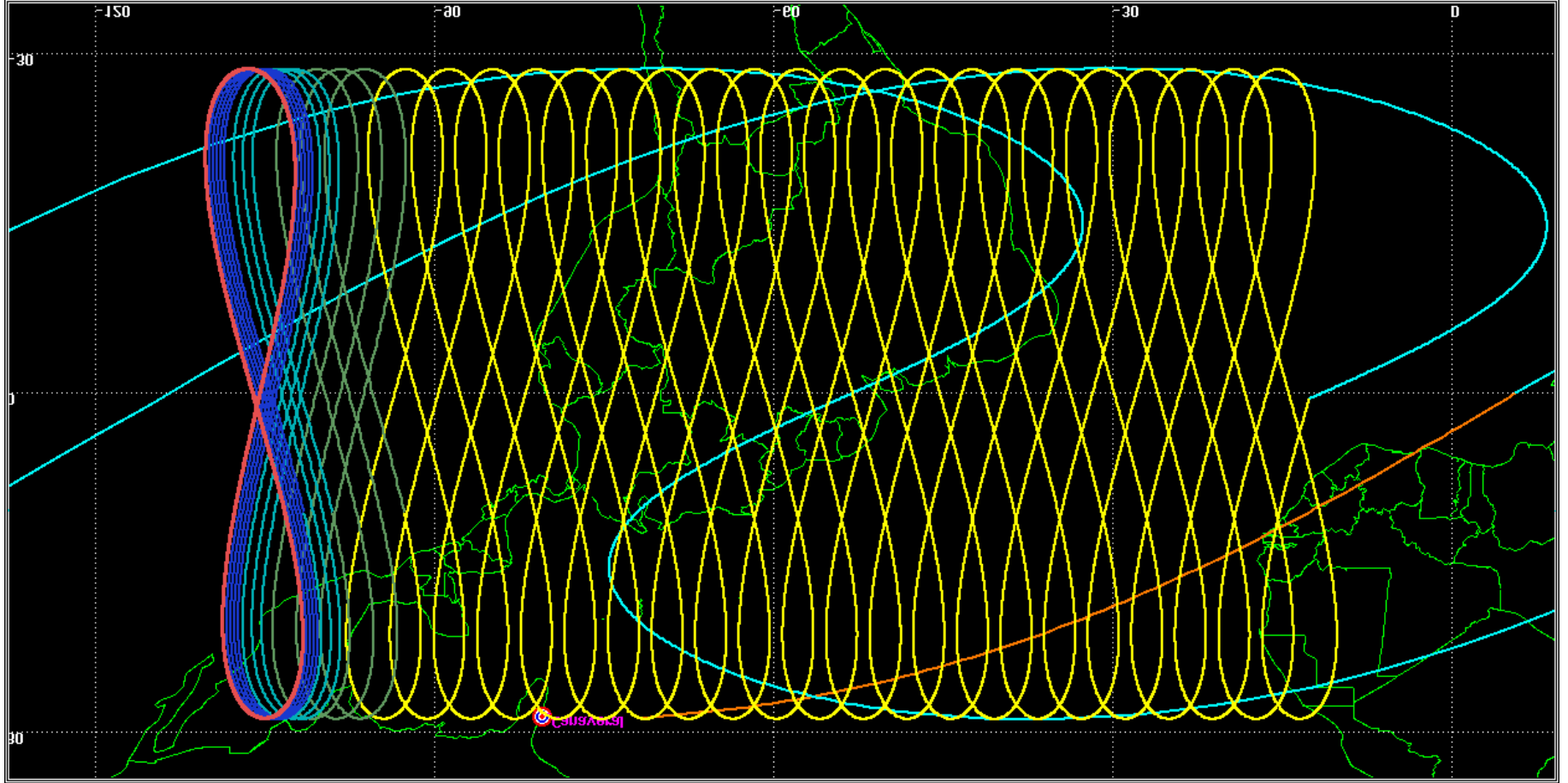
Ascent
Parking Orbit

GTO
SuperSynch

Phasing Orbit 1
Phasing Orbit 2

Phasing Orbit 3
Mission Orbit

Parking Orbit
 Ascent
 Supersynch
 GTO
 Phasing Orbit 2
 Phasing Orbit 1
 Mission Orbit
 Phasing Orbit 3



FAME Ground Track for Nominal Orbit Transfer Plan

AKM Firing

- AKM Firing from GTO to SuperSynch
 - Maneuver Time: 11/1/04 10:50:09
 - $\Delta V = 1478$ m/s
 - Moves FAME from 185 x 36108 km GTO to 36108 x 36123 km orbit for AKM Disposal
 - SA = 76 deg
 - Sun Angles measured from Instrument +Z axis
 - Sun angle of 180° has sun normal to deployed sun shield.
 - Sun angle of 90° is edge-on to sun shield.
 - Sun angle of 0° has sun shining directly on instrument.

AKM Jettison

- AKM Jettison using Spring Separation
 - Jettison after AKM firing to minimize thermal soak-back.
 - Total $\Delta V = 1$ ft/s (0.3 m/sec)
 - Observatory $\Delta V = 0.126$ ft/sec (13%)
 - AKM $\Delta V = -0.874$ ft/sec (87%)
 - AKM Velocity decreased by jettison
 - AKM Disposal Orbit altitude is decreased by jettison.
 - Pre-jettison orbit apogee biased 15 km above AKM Disposal Orbit so final orbit meets GEO + 320 km requirement.
 - FAME is pushed higher into 36108 x 36125 km orbit by jettison.

AKM Recontact

- FAME and AKM start at origin.
- Spring separation occurs at 0° Pitch / 0° Yaw.
- AKM stays at origin, FAME starts moving ahead in-track.
- FAME altitude and orbit period increased by ΔV of spring separation.
- Period difference eventually causes FAME to fall behind AKM.
- Each point represents 30 min elapsed time.
- Minimum 10 km separation after 6.5 hours
- Separation grows to >150 km within 2 days.

Radial Position (km)

Phasing Maneuver 1

- Reducing Perigee and Phasing with Mission Orbit ground track
 - Maneuver Time: 11/21/04 1:30:49
 - Maneuver near Descending Node (moving South)
 - Decrease Perigee by 293 km
 - $\Delta V = 5.3 \text{ m/s}$
 - SA = 130 deg
 - Burn Time = 3.8 min (22 N / 5# total thrust)

Phasing Maneuver 2

- Reducing Perigee to phase with Mission Orbit
 - Maneuver Time: 11/24/04 1:46:55
 - Maneuver near Descending Node (moving South)
 - Decrease Perigee by 219 km
 - $\Delta V = 4.0$ m/s
 - SA = 131 deg
 - Burn Time = 2.9 min (22 N / 5# total thrust)

Phasing Maneuver 3

- Reducing Perigee to phase with Mission Orbit
 - Maneuver Time: 11/27/04 1:46:14
 - Maneuver near Descending Node (moving South)
 - Decrease Perigee by 88 km
 - $\Delta V = 1.6 \text{ m/s}$
 - SA = 131 deg
 - Burn Time = 1.1 min (22 N / 5# total thrust)

Phasing Maneuver 4

- Mission Orbit Insertion
 - Maneuver Time: 12/2/04 1:33:51
 - Maneuver near Descending Node
 - Decrease Perigee by 59 km
 - $\Delta V = 1.1$ m/s
 - SA = 131 deg
 - Burn Time = 0.8 min (22 N / 5# total thrust)
 - Five day dwell prior to maneuver allows optimal orbit determination.
 - Maneuver timing synchronizes ground track with Desired LAN.
 - Size of final Phasing Maneuver limits orbit errors which minimizes ground track drift.

First State	Date		Mission Time (sec) (min)	
Main engine ignition	10/30/04 21:19:36	T + 0	0	0.0
Solid motor ignition	10/30/04 21:19:36	T + 0	0	0.0
Solid motor burnout	10/30/04 21:20:39	T + 63s	63	1.1
Solid motor separation (2) *	10/30/04 21:20:42	T + 66s	66	1.1
Solid motor separation (2) **	10/30/04 21:20:43	T + 67s	67	1.1
MECO (M) ***	10/30/04 21:23:57	T + 261s	261	4.4
Second Stage				
Activate stage I/II separation bolts	10/30/04 21:24:05	M + 8s	269	4.5
Stage II ignition	10/30/04 21:24:10	M + 13.5s	275	4.6
Fairing separation	10/30/04 21:24:36	M + 39s	300	5.0
SECO (S1)	10/30/04 21:30:52	M + 415s	676	11.3
Stage II ignition	10/30/04 21:41:02	S1 + 610s	1286	21.4
Stage II burnout (S2)	10/30/04 21:41:23	S1 + 631s	1307	21.8
Third Stage				
Activate spin rockets, start Stage III sequencer	10/30/04 21:42:13	S2 + 50s	1357	22.6
Separate Stage II	10/30/04 21:42:16	S2 + 53s	1360	22.7
Stage III ignition	10/30/04 21:42:53	S2 + 90s	1397	23.3
Stage III burnout	10/30/04 21:44:20	S2 + 177s	1484	24.7
Spacecraft Separation ****	10/30/04 21:46:13	S2 + 290s	1597	26.6
AKM				
Apogee Trim Maneuver	10/31/04 18:53:11	AKM - 15.9h		
AKM Firing	11/01/04 10:50:09	AKM + 0		
FAME w/o AKM				
Phasing Maneuver 1	11/21/04 01:30:49	AKM + 19.6d		
Phasing Maneuver 2	11/24/04 01:46:55	AKM + 22.6d		
Phasing Maneuver 3	11/27/04 01:46:14	AKM + 25.6d		
Mission Orbit Insertion	12/02/04 01:33:51	AKM + 30.6d		

* - First two of four separated

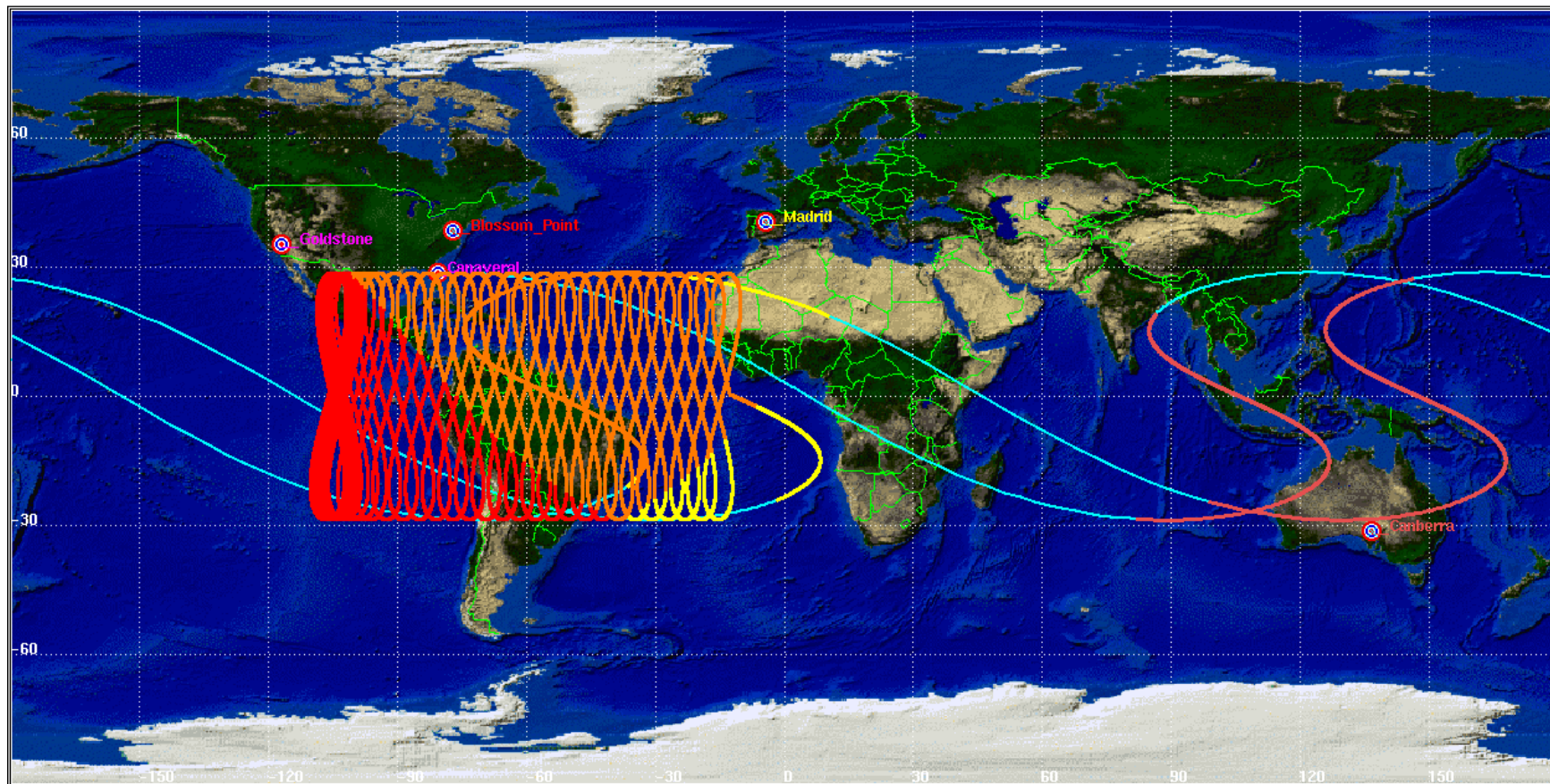
** - Second two of four separated

*** - Main engine cutoff)

**** - Spacecraft includes FAME and attached AKM.

FAME Coverage During Orbit Transfer

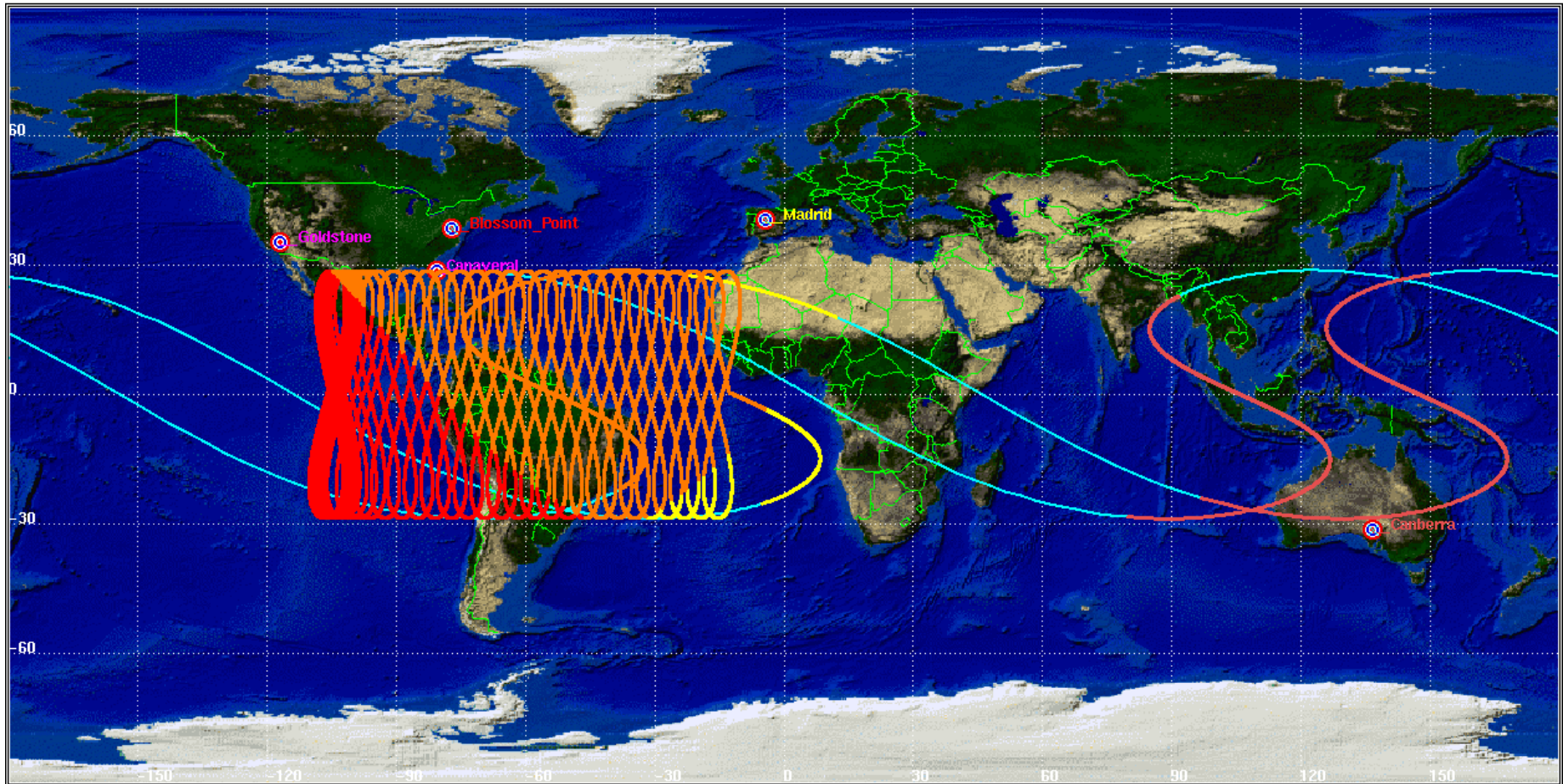
Blossom Point + DSN Stations (5° min elev)



Blossom Point Coverage
Canberra Coverage
Madrid Coverage
Joint Blossom Point/Madrid Coverage

FAME Coverage During Orbit Transfer

Blossom Point + DSN Stations (2° min elev)



Blossom Point Coverage
Canberra Coverage
Madrid Coverage
Joint Blossom Point/Madrid Coverage